INSTRUCTION MANUAL

# CS115

# Barometric Pressure Sensor

3/03

# Warranty and Assistance

The **CS115 BAROMETRIC PRESSURE SENSOR** is warranted by CAMPBELL SCIENTIFIC, INC. to be free from defects in materials and workmanship under normal use and service for twelve (12) months from date of shipment unless specified otherwise. Batteries have no warranty. CAMPBELL SCIENTIFIC, INC.'s obligation under this warranty is limited to repairing or replacing (at CAMPBELL SCIENTIFIC, INC.'s option) defective products. The customer shall assume all costs of removing, reinstalling, and shipping defective products to CAMPBELL SCIENTIFIC, INC. CAMPBELL SCIENTIFIC, INC. will return such products by surface carrier prepaid. This warranty shall not apply to any CAMPBELL SCIENTIFIC, INC. products which have been subjected to modification, misuse, neglect, accidents of nature, or shipping damage. This warranty is in lieu of all other warranties, expressed or implied, including warranties of merchantability or fitness for a particular purpose. CAMPBELL SCIENTIFIC, INC. is not liable for special, indirect, incidental, or consequential damages.

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**CAMPBELL SCIENTIFIC, INC.**
RMA#_____
815 West 1800 North
Logan, Utah 84321-1784

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# CS115 Table of Contents

*PDF viewers note: These page numbers refer to the printed version of this document. Use the Adobe Acrobat® bookmarks tab for links to specific sections.*



## *Figures*



## *Tables*

# CS115 Barometric Pressure Sensor

*The CS115 Barometric Pressure Sensor uses the resonant silicon technology pressure sensor developed by Druck. The sensor outputs a variable frequency which can be measured using the datalogger's period averaging instruction or pulse count instruction. The entire process is essentially digital from sensor element to datalogger, ensuring the highest precision and most accurate reading possible.*


## 1. Introduction

The sensor comprises two elements, one acting as a pressure sensitive diaphragm and the other acting as a resonator. Pressure variations deflect the sensitive diaphragm and change the sensor's resonant frequency. The resonant frequency is measured, corrected for the effects of temperature and non-linearity, and then output as a frequency signal. The sensor is characterized over the full temperature and pressure range, and the corrections are stored in the sensor's non-volatile memory. It can be operated in a triggered or continuous mode. In the triggered mode the datalogger switches 12 VDC power to the barometer before the measurement. The datalogger then powers down the barometer after the measurements to conserve power.

# 2. Specifications

## 2.1 Performance

| | |
|---|---|
| Measurement Range: | 600 mb to 1100 mb (hPa) |
| Operating Temperature Range: | -40°C to +60°C |
| Humidity Range: | non-condensing |
| Media Compatibility: | non-corrosive gas |
| Total Accuracy[1]: | |
| at 20°C | ±0.3 mb |
| -10°C to +50°C | ±0.5 mb |
| -20°C to +60°C | ±1.5 mb |
| -40°C to +60°C | ±2.0 mb |
| Long-term Stability: | <0.11 mb per year (100 ppm) |
| Overpressure Limit: | 1375 mb |

## 2.2 Electrical

| | |
|---|---|
| Supply Voltage: | 9.5 V to 24 VDC |
| Current Consumption: | 8 mA nominal |
| Output Frequency: | 600 Hz to 1100 Hz |
| Frequency Output: | -2.5 to +2.5 VDC zero-crossing square wave |
| External Trigger Voltages: | ON 1 to 24 VDC<br>OFF 0 VDC |
| Warm-up Time: | <2 seconds (-40°C to +60°C) |
| EMC Compatibility: | Emissions – BS EN50081-1<br>Immunity – BS EN61000-6-2 |

## 2.3 Physical

| | |
|---|---|
| Dimensions (Main Box): | 2.36" x 2.36" x 1.15"<br>(6.0 cm x 6.0 cm x 2.9 cm) |
| Weight: | 4.4 oz (125 g) |
| Mounting Hole Centers: | 3 inches (7.62 cm) |
| Pressure Connector: | 0.16" (0.4 cm) barbed hose |

**NOTE** The black outer jacket of the cable is Santoprene® rubber. This compound was chosen for its resistance to temperature extremes, moisture, and UV degradation. However, this jacket will support combustion in air. It is rated as slow burning when tested according to U.L. 94 H.B. and will pass FMVSS302. Local fire codes may preclude its use inside buildings.

[1] Non-linearity, hysteresis, and repeatability over calibrated temperature range

# 3. Installation

## 3.1 Venting and Condensation

To prevent condensation, install the sensor in an environmentally protected enclosure, complete with desiccant which should be changed at regular intervals. As the sensor must detect the external ambient pressure the enclosure must *not* be 'hermetically sealed'.

**CAUTION** Failure to protect the sensor from condensation may result in permanent damage.

**NOTE** If it is necessary to make a vent hole on the outer wall of an enclosure, do not make the hole on one of the vertical side walls, as wind blowing around it can cause transient changes in pressure.

## 3.2 Mounting

The mounting holes for the sensor are one-inch-centered, and will mount directly onto the holes on the backplates of the Campbell Scientific enclosures. Mount the sensor with the pneumatic connector pointing vertically downwards to prevent condensation collecting in the pressure cavity, and also to ensure that water cannot enter the sensor.


*FIGURE 3-1. Mounting CS115*

As you mount the sensor onto the backplate of the enclosure, place the fork lug under the mounting screw to accomplish the proper grounding of the sensor as shown in Figure 3-1.

## 3.3 Jumper Settings

The CS115 has two operating modes, ‘continuous’ and ‘triggered’. It is normally shipped in the ‘triggered’ mode, in which the unit is turned on and off by applying signal to the blue wire (EXT. TRIG.) using a datalogger’s control port. In this mode, power consumption is minimized, but the sensor is subject to a 2-second ‘warm-up’ delay after it is turned on. You can also configure the unit for the ‘continuous’ mode to avoid the need for the delay, in which the sensor is powered on continuously. This can be achieved either by connecting the blue wire (EXT. TRIG.) to a continuous 1 to 24 VDC supply (to 5 V or 12 V channel of the datalogger) or by changing the jumper position connecting the pins on the circuit board. See Figure 3-2 below.

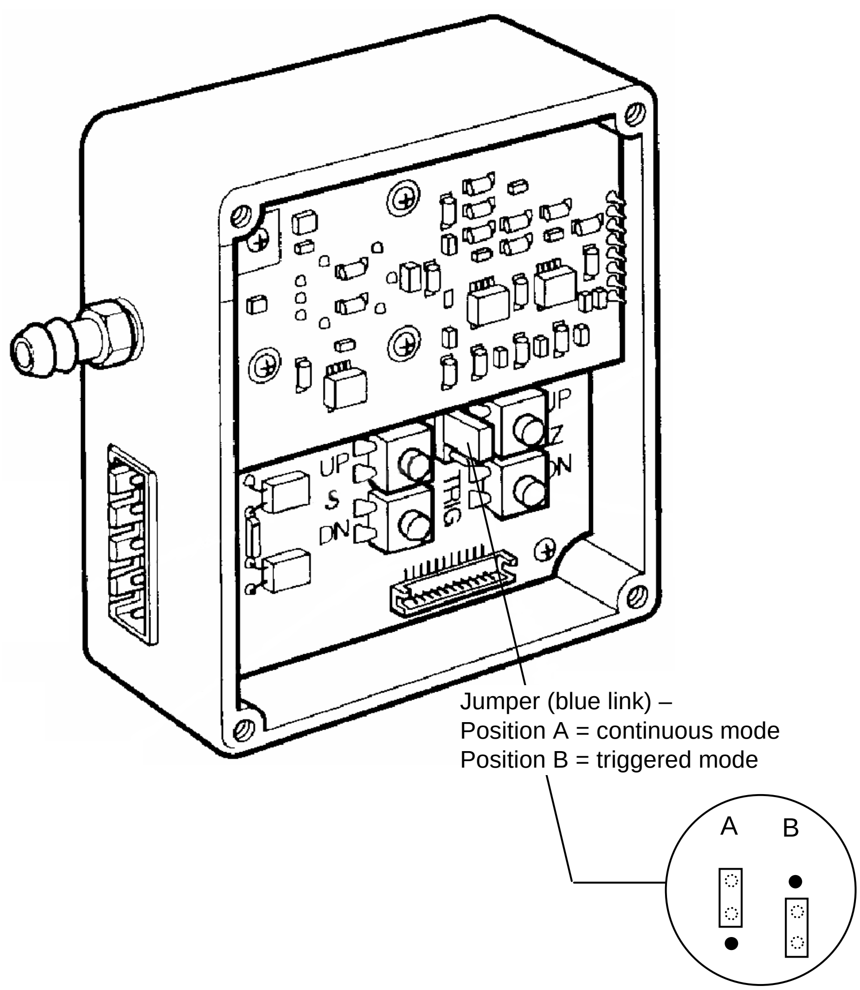


*FIGURE 3-2. Jumper Settings on CS115*

# 4. Wiring

The CS115 wiring instructions for the example programs are shown in Table 4-1. For dataloggers CR500, CR510, CR10(X), CR23X, and CR5000, analog channel is used for period averaging measurement. For CR7, 21X and CR9000 pulse channel is used for pulse count measurement.

**TABLE 4-1. Wiring for Example Programs**

| Wire Color | Description | CR10(X) | CR23X | 21X | CR5000 |
|---|---|---|---|---|---|
| Green | Frequency Out | SE6 | SE24 | P1 | SE33 |
| Red | Supply (12Vdc) | 12V | 12V | 12V | 12V |
| Black | Power Ground | G | G | ⏚ | G |
| Yellow | Signal Ground | AG | ⏚ | ⏚ | ⏚ |
| Blue | External Trigger | C8 | C1 | C6 | C1 |
| Clear | Shield | G | G | ⏚ | G |

# 5. Programming

There are two ways to measure the output of the CS115. The preferred way is to use the period averaging instruction available with the CR500, CR510, CR10(X), CR23X and CR5000 dataloggers. This instruction determines the period of the output signal averaged over a user-specified number of cycles and outputs it in kHz.

If you have a datalogger that does not support the period averaging instruction (e.g., 21X, CR7 or CR9000), a pulse count instruction can be used to measure the CS115.

Atmospheric pressure changes little with time. In most weather station applications measuring pressure once an hour is adequate.

In Example 1, the datalogger turns on the CS115 one minute before the top of the hour with a control port. As in the example, the execution interval *must* be one minute or less. The datalogger measures the CS115 on the hour, and then it turns the CS115 off.

In Example 2, the CS115 is measured every execution interval. The datalogger turns the CS115 on and waits two seconds for it to warm up before the measurement is made. The execution interval *must* be long enough to accommodate the two-second warm-up delay plus all the other measurements and processing instructions in the program.

Example 3 resembles Example 1 in every way, but it is for the CR23X.

In Example 4, the CR5000 measures the CS115 once an hour in a program that runs at 10 Hz. With the CR5000, the period averaging instruction has to be executed every scan and cannot be inside the “If” statement. The measured value, therefore, is first written into a temporary variable called "CS115_Freq".

Once the CS115 is turned on one minute before every hour, and the correct measurement is made, it is then copied into the current variable called "Pressure". The sensor is then turned off immediately following the measurement. In this example, the CR5000 measures the CS115 once every hour while measuring other sensors at 10 Hz.

In Example 5, the 21X turns on the CS115 one minute before the top of the hour, and on the hour it measures the CS115 using the pulse count instruction. The execution interval should be set at 1 second, and the configuration code for Pulse instruction (P3) should be set at 24, Low Level AC, 16-bit, Output in Hz. When this option is selected, two adjacent 8-bit pulse counters (Pulse Input channels 1 and 2) are combined into one input channel (Pulse Input channel 1) to form a 16-bit accumulator. Therefore, Pulse Input channel 2 cannot be used. You can also choose to use Pulse Input channel 3, in which case Pulse Input channels 4 will be combined with Pulse Input channel 3 to form a 16-bit accumulator. In this mode, the 21X's execution interval *must* be less than one minute. If the execution interval is longer than one minute, you will get an error, because the 16-bit pulse accumulator will overflow counting the signal from the CS115 when it outputs close to 1100 Hz (1100 mb of barometric pressure).

In the example programs above, the pressure is reported in millibars (mb). To report pressure in different units, multiply the measured pressure by the appropriate conversion factor using the P37 (Z=X*F) instruction for the CR500, CR510, CR10(X), CR23X, 21X and CR7, or by adding an expression for the CR5000 and CR9000. See Table 5-1 below for conversion factors.

**TABLE 5-1. Conversion Factors for Alternative Pressure Units**

| To Find | Multiply by |
|---|---|
| hPa | 1.0 |
| kPa | 0.1 |
| mm of Hg | 0.75006 |
| in of Hg | 0.02953 |
| psi | 0.0145 |
| atm | 0.00099 |
| torr | 0.75006 |

## 5.1 Period Averaging Measurement Examples

### 5.1.1 Period Averaging Measurement Example for CR10(X)

**EXAMPLE 1. Sample Program for CR10(X)**

```
;{CR10X}
;
*Table 1 Program
  01: 1             Execution Interval (seconds)

;Turn on CS115 one minute before the hour
;
1:  If time is (P92)
  1:   59           Minutes (Seconds --) into a
  2:   60           Interval (same units as above)
  3:   48*          Set Port 8* High

;Measure CS115 at the top of the hour
;
2:  If time is (P92)
  1:   0            Minutes (Seconds --) into a
  2:   60           Interval (same units as above)
  3:   30           Then Do

3:  Period Average (SE) (P27)
  1:   1            Reps
  2:   14           200 kHz Max Freq @ 2 V Peak to Peak, Freq Output
  3:   6*           SE Channel
  4:   10           No. of Cycles
  5:   5            Timeout (units = 0.01 seconds)
  6:   1*           Loc [ P_mb     ]
  7:   1000         Mult
  8:   0.0          Offset

;Turn off CS115
;
4:  Do (P86)
  1:   58*          Set Port 8* Low

5:  End (P95)

6:  If time is (P92)
  1:   0            Minutes (Seconds --) into a
  2:   60           Interval (same units as above)
  3:   10           Set Output Flag High (Flag 0)

7:  Real Time (P77)
  1:   0110         Day,Hour/Minute (midnight = 0000)
```

```
8:  Sample (P70)
   1:   1              Reps
   2:   1*             Loc [ P_mb     ]

*Table 2 Program
   02:  0.0000         Execution Interval (seconds)

*Table 3 Subroutines

End Program

-Input Locations-
1 P_mb

*  Proper entries will vary with program and datalogger channel, and input location assignments.
```

### 5.1.2 Period Averaging Measurement Example for CR10(X) in a Slow Executing Program

**EXAMPLE 2. Sample Program for CR10(X)**

```
;{CR10X}
;
*Table 1 Program
   01:  10             Execution Interval (seconds)

;Turn on CS115
;
1:  Do (P86)
   1:   48*            Set Port 8* High

;Give 2 second delay for CS115 to settle
;
2:  Excitation with Delay (P22)
   1:   1              Ex Channel
   2:   0              Delay W/Ex (0.01 sec units)
   3:   200            Delay After Ex (0.01 sec units)
   4:   0              mV Excitation

3:  Period Average (SE) (P27)
   1:   1              Reps
   2:   14             200 kHz Max Freq @ 2 V Peak to Peak, Freq Output
   3:   6*             SE Channel
   4:   10             No. of Cycles
   5:   5              Timeout (units = 0.01 seconds)
   6:   1*             Loc [ P_mb     ]
   7:   1000           Mult
   8:   0.0            Offset
```

```
;Turn off CS115
;
4:  Do (P86)
   1:   58*          Set Port 8* Low

5:  If time is (P92)
   1:   0            Minutes (Seconds --) into a
   2:   60           Interval (same units as above)
   3:   10           Set Output Flag High (Flag 0)

6:  Real Time (P77)
   1:   0110         Day,Hour/Minute (midnight = 0000)

7:  Sample (P70)
   1:   1            Reps
   2:   1*           Loc [ P_mb      ]

*Table 2 Program
   02:  0.0000       Execution Interval (seconds)

*Table 3 Subroutines

End Program

-Input Locations-
1 P_mb

*  Proper entries will vary with program and datalogger channel, and input location assignments.
```

### 5.1.3 Period Averaging Measurement Example for CR23X

**EXAMPLE 3.  Sample Program for CR23X**

```
;{CR23X}
;
*Table 1 Program
   01:  1            Execution Interval (seconds)

;Turn on CS115 one minute before the hour
;
1:  If time is (P92)
   1:   59           Minutes (Seconds --) into a
   2:   60           Interval (same units as above)
   3:   41*          Set Port 1* High

;Measure CS115 at the top of the hour
;
2:  If time is (P92)
   1:   0            Minutes (Seconds --) into a
   2:   60           Interval (same units as above)
   3:   30           Then Do
```

```
3:  Period Average (SE) (P27)
    1:   1              Reps
    2:   14             200 kHz Max Freq @ 500 mV Peak to Peak, Freq Output
    3:   24*            SE Channel
    4:   10             No. of Cycles
    5:   5              Timeout (units = 0.01 seconds)
    6:   1*             Loc [ P_mb      ]
    7:   1000           Mult
    8:   0.0            Offset

;Turn off CS115
;

4:  Do (P86)
    1:   51*            Set Port 1* Low

5:  End (P95)

6:  If time is (P92)
    1:   0              Minutes (Seconds --) into a
    2:   60             Interval (same units as above)
    3:   10             Set Output Flag High (Flag 0)

7:  Real Time (P77)
    1:   0110           Day,Hour/Minute (midnight = 0000)

8:  Sample (P70)
    1:   1              Reps
    2:   1*             Loc [ P_mb      ]

*Table 2 Program
    02:  0.0000         Execution Interval (seconds)

*Table 3 Subroutines

End Program

-Input Locations-
1 P_mb      1 1 1

*  Proper entries will vary with program and datalogger channel, and input location assignments.
```

### 5.1.4 Period Averaging Measurement Example for CR5000 in a Fast Executing Program at 10Hz

**EXAMPLE 4. Sample Program for CR5000**

```
 'CR5000
'
'Sample Program to Measure CS115 Barometric Pressure Sensor
'
'

Public    CS115_Freq, Pressure
Units     Pressure = mb

BeginProg

Scan (100,mSec,3,0)

'Turn  CS115 ON one minute before every hour
'
    If (IfTime (59,60,min)) Then WriteIO (1,1)

'Period Avgeraging instruction must be executed every scan, and
'cannot be inside the "If" statement.   The measured value, therefore, is
'first written into a temporary variable called "CS115_Freq".
    PeriodAvg (CS115_Freq,1,mV5000,33,0,1,10,20,1.0,0)

'Once CS115 is turned on one minute before every hour, and
'the correct measurement is made, it is copied into the current variable
'called "Pressure".   The sensor is, then, turned off.
'
    If IfTime(0,60,min) Then

        Pressure = CS115_Freq

'Turns CS115 OFF
 '
        WriteIO (1,0)

    EndIf

NextScan

EndProg
```

## 5.2 Pulse Count Measurement Example

### 5.2.1 Pulse Count Measurement Example for 21X

**EXAMPLE 5. Sample Program for 21X**

```
;{21X}
;
*Table 1 Program
  01:  1            Execution Interval (seconds)

1:  If time is (P92)
  1:   59           Minutes into a
  2:   60           Minute Interval
  3:   46*          Set Port 6* High

2:  If time is (P92)
  1:   0            Minutes into a
  2:   60           Minute Interval
  3:   30           Then Do

3:  Pulse (P3)
  1:   1            Reps
  2:   1*           Pulse Input Channel
  3:   24           Low Level AC, 16 Bit, Output Hz
  4:   1*           Loc [ P_mb     ]
  5:   1            Mult
  6:   0.0          Offset

4:  Do (P86)
  1:   56*          Set Port 6* Low

5:  End (P95)

6:  If time is (P92)
  1:   0            Minutes into a
  2:   60           Minute Interval
  3:   10           Set Output Flag High

7:  Real Time (P77)
  1:   0110         Day,Hour/Minute (midnight = 0000)

8:  Resolution (P78)
  1:   1            High Resolution

9:  Sample (P70)
  1:   1            Reps
  2:   1            Loc [ P_mb     ]

*Table 2 Program
  02:  0.0000       Execution Interval (seconds)
```

```
*Table 3 Subroutines

End Program

-Input Locations-
1 P_mb      1 1 1

*  Proper entries will vary with program and datalogger channel, and input location assignments.
```

## 5.3 Output Resolution

When storing the values from the CS115 to a datalogger's final storage location, or to a data table, care must be taken to choose suitable scaling of the reading or to store the value with adequate resolution to avoid losing useful resolution of the pressure measurement. The default resolution (Low Resolution) for the Campbell Scientific dataloggers is limited to a maximum of four digits. Even then the maximum digit value that can be displayed is 6999 (7999 for the CR5000/9000 dataloggers). If you use this option with barometric data scaled in millibars (hPa), a reading above 699.9 mb (799.9 mb for CR5000/9000) will lose one digit of resolution, e.g. at 900mb, the resolution is limited to 1 mb.

To retain 0.1 mb resolution, you either need to deduct a fixed offset from the reading before it is stored to avoid exceeding the 699.9 (or 799.9) threshold, or output the barometric reading in high resolution format. This can be done by using the Resolution (P78) instruction in the CR500, CR510, CR10(X), CR23X, CR7 and 21X dataloggers, or the IEEE4 format for the CR5000 and CR9000.

# 6. Correcting Pressure to Sea Level

The weather service, most airports, radio stations, and television stations reduce the atmospheric pressure to a common reference (sea level). Equation 1 can be used to find the difference in pressure between the sea level and the site. That value (*dP*) is then added to the offset (0.0 mb) in the measurement instruction. U. S. Standard Atmosphere and dry air were assumed when Equation 1 was derived (Wallace, J. M. and P. V. Hobbes, 1977: *Atmospheric Science: An Introductory Survey*, Academic Press, pp. 59-61).

$$dP = 1013.25\left\{1-\left(1-\frac{E}{44307.69231}\right)^{5.25328}\right\} \quad (1)$$

The value *dP* is in millibars and the site elevation, *E*, is in meters. Add *dP* value to the offset in the measurement instruction.

Use Equation (2) to convert feet to meters.

$$E(m) = \frac{E(ft)}{3.281 ft/m} \quad (2)$$

The corrections involved can be significant: e.g., at 1000 mb and 20°C, barometric pressure will decrease by 1.1 mb for every 10 meter increase in altitude.

# 7. Maintenance and Calibration

Since the sensor is semi-sealed, minimum maintenance is required.

1. Visually inspect the cable connection to ensure it is clean and dry.
2. Ensure that the ground connection (shield) is secure and clean.
3. Visually inspect the casing for damage.
4. Ensure that the pneumatic connection and pipe are secure and undamaged.

The external case can be cleaned with a damp, lint-free cloth and a mild detergent solution.

Druck recommends recalibrating the CS115 every year. Contact Campbell Scientific, Inc., phone (435) 753-2342, for an RMA number before returning the sensor for recalibration. You may also return the unit directly to Druck USA for recalibration.

Should you lose the five terminal connector (p/n 16004), the replacement part can be purchased from Campbell Scientific, Inc. Contact Campbell Scientific, Inc. to purchase the part.

**CAUTION** The CS115 is sensitive to static when the backplate is removed. To avoid damage, take adequate anti-static measures when handling.

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